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☐	L6	L5 and (spiral$2 or curv$4 or helix or helical$2)	77
☐	L5	L4 and ((magnetic adj resonance) or MRI or NMR)	204
☐	L4	l3 and (water with select$4)	1150
☐	L3	l2 and (fat with select$4)	3982
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☐ 1. Document ID: US 20050017717 A1

Using default format because multiple data bases are involved.

L7: Entry 1 of 28 File: PGPB Jan 27, 2005

PGPUB-DOCUMENT-NUMBER: 20050017717
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20050017717 A1

TITLE: Chemical species suppression for MRI imaging using spiral trajectories with off-resonance correction

PUBLICATION-DATE: January 27, 2005

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY	RULE-47
Duerk, Jeffrey L.	Avon Lake	OH	US	
Lewin, Jonathan S.	Baltimore	MD	US	
Moriguchi, Hisamoto	Cleveland	OH	US	

US-CL-CURRENT: 324/307; 324/306, 324/309

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw De

☐ 2. Document ID: US 20040260470 A1

L7: Entry 2 of 28 File: PGPB Dec 23, 2004

PGPUB-DOCUMENT-NUMBER: 20040260470
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20040260470 A1

TITLE: Conveyance scheduling and logistics system

PUBLICATION-DATE: December 23, 2004

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY	RULE-47
Rast, Rodger H.	Gold River	CA	US	

US-CL-CURRENT: 701/300; 705/7

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw De

☐ 3. Document ID: US 20040167390 A1

L7: Entry 3 of 28 File: PGPB Aug 26, 2004

PGPUB-DOCUMENT-NUMBER: 20040167390
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20040167390 A1

TITLE: Assessing the condition of a joint and devising treatment

PUBLICATION-DATE: August 26, 2004

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY	RULE-47
Alexander, Eugene J.	Palo Alto	CA	US	
Andriacchi, Thomas P.	Los Altos Hills	CA	US	
Lang, Philipp	Redwood City	CA	US	
Steines, Daniel	Palo Alto	CA	US	

US-CL-CURRENT: 600/410

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw De

☐ 4. Document ID: US 20030117136 A1

L7: Entry 4 of 28 File: PGPB Jun 26, 2003

PGPUB-DOCUMENT-NUMBER: 20030117136
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20030117136 A1

TITLE: Method and apparatus for measuring and correcting motion effects using navigator echoes

PUBLICATION-DATE: June 26, 2003

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY	RULE-47
Wang, Yi	Pittsburgh	PA	US	
Nguyen, Thanh D.	Pittsburgh	PA	US	

US-CL-CURRENT: 324/306; 324/307, 324/309

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw De

☐ 5. Document ID: US 20030112921 A1

L7: Entry 5 of 28 File: PGPB Jun 19, 2003

PGPUB-DOCUMENT-NUMBER: 20030112921
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20030112921 A1

TITLE: Methods and devices for analysis of x-ray images

PUBLICATION-DATE: June 19, 2003

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY	RULE-47
Lang, Philipp	Lexington	MA	US	
Steines, Daniel	Palo Alto	CA	US	

US-CL-CURRENT: 378/54

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw De

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☐ 6. Document ID: US 20020193680 A1

L7: Entry 6 of 28 File: PGPB Dec 19, 2002

PGPUB-DOCUMENT-NUMBER: 20020193680
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20020193680 A1

TITLE: Magnetic resonance method and apparatus for generating respective images from spin ensembles exhibiting different chemical shift

PUBLICATION-DATE: December 19, 2002

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY	RULE-47
Feiweier, Thorsten	Spardorf		DE	

US-CL-CURRENT: 600/410

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw De

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☐ 7. Document ID: US 20020146371 A1

L7: Entry 7 of 28 File: PGPB Oct 10, 2002

PGPUB-DOCUMENT-NUMBER: 20020146371
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20020146371 A1

TITLE: Methods for development and use of diagnostic and therapeutic agents

PUBLICATION-DATE: October 10, 2002

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY	RULE-47
Li, King Chuen	Bethesda	MD	US	
Bednarski, Mark David	Los Altos	CA	US	

US-CL-CURRENT: 424/1.73; 424/9.35, 424/9.43, 424/9.6, 435/6

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw De

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8. Document ID: US 20020042567 A1

L7: Entry 8 of 28 File: PGPB Apr 11, 2002

PGPUB-DOCUMENT-NUMBER: 20020042567
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20020042567 A1

TITLE: Magnetic resonance tomography apparatus and method employing a true FISP sequence with improved off-resonant behavior of two spin ensembles

PUBLICATION-DATE: April 11, 2002

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY	RULE-47
Heid, Oliver	Gunzenhausen		DE	

US-CL-CURRENT: 600/410; 324/307

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw De

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9. Document ID: US 6841997 B2

L7: Entry 9 of 28 File: USPT Jan 11, 2005

US-PAT-NO: 6841997
DOCUMENT-IDENTIFIER: US 6841997 B2

TITLE: Magnetic resonance method and apparatus for generating respective images from spin ensembles exhibiting different chemical shift

DATE-ISSUED: January 11, 2005

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Feiweier; Thorsten	Spardorf			DE

US-CL-CURRENT: 324/307; 324/309

Full | Title | Citation | Front | Review | Classification | Date | Reference | Claims | KWIC | Draw De

☐ 10. Document ID: US 6791323 B2

L7: Entry 10 of 28 File: USPT Sep 14, 2004

US-PAT-NO: 6791323
DOCUMENT-IDENTIFIER: US 6791323 B2

TITLE: Method and apparatus for measuring and correcting motion effects using navigator echoes

DATE-ISSUED: September 14, 2004

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Wang; Yi	Pittsburgh	PA		
Nguyen; Thanh D.	Pittsburgh	PA		

US-CL-CURRENT: 324/309

Full | Title | Citation | Front | Review | Classification | Date | Reference | | | Claims | KMC | Draw De

☐ 11. Document ID: US 6749868 B1

L7: Entry 11 of 28 File: USPT Jun 15, 2004

US-PAT-NO: 6749868
DOCUMENT-IDENTIFIER: US 6749868 B1

TITLE: Protein stabilized pharmacologically active agents, methods for the preparation thereof and methods for the use thereof

DATE-ISSUED: June 15, 2004

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Desai; Neil P.	Los Angeles	CA		
Tao; Chunlin	Beverly Hills	CA		
Yang; Andrew	Rosemead	CA		
Louie; Leslie	Montebello	CA		
Yao; Zhiwen	Culver City	CA		
Soon-Shiong; Patrick	Los Angeles	CA		
Magdassi; Shlomo	Jerusalem			IL

US-CL-CURRENT: 424/491; 424/489, 424/490

Full | Title | Citation | Front | Review | Classification | Date | Reference | | | Claims | KMC | Draw De

☐ 12. Document ID: US 6307368 B1

L7: Entry 12 of 28 File: USPT Oct 23, 2001

US-PAT-NO: 6307368
DOCUMENT-IDENTIFIER: US 6307368 B1

TITLE: Linear combination steady-state free precession MRI

DATE-ISSUED: October 23, 2001

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Vasanawala; Shreyas S.	Mountain View	CA		
Pauly; John M.	Redwood City	CA		
Nishimura; Dwight G.	Palo Alto	CA		

US-CL-CURRENT: 324/309; 324/300, 324/307, 324/311

Full | Title | Citation | Front | Review | Classification | Date | Reference | | | Claims | KWIC | Draw D

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13. Document ID: US 6275040 B1

L7: Entry 13 of 28 File: USPT Aug 14, 2001

US-PAT-NO: 6275040
DOCUMENT-IDENTIFIER: US 6275040 B1

TITLE: Designing spectral-spatial pulses

DATE-ISSUED: August 14, 2001

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Zur; Yuval	34752, Haifa			IL

US-CL-CURRENT: 324/320

Full | Title | Citation | Front | Review | Classification | Date | Reference | | | Claims | KWIC | Draw D

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14. Document ID: US 6181134 B1

L7: Entry 14 of 28 File: USPT Jan 30, 2001

US-PAT-NO: 6181134
DOCUMENT-IDENTIFIER: US 6181134 B1

TITLE: Magnetic resonance imaging of the distribution of a marker compound without obtaining spectral information

DATE-ISSUED: January 30, 2001

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Wald; Lawrence L.	Cambridge	MA		

US-CL-CURRENT: 324/307; 324/309

Full | Title | Citation | Front | Review | Classification | Date | Reference | | | Claims | KWIC | Draw. De

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15. Document ID: US 6174700 B1

L7: Entry 15 of 28 File: USPT Jan 16, 2001

US-PAT-NO: 6174700
DOCUMENT-IDENTIFIER: US 6174700 B1

TITLE: Purification of a polypeptide compound having a polysaccharide binding domain by affinity phase separation

DATE-ISSUED: January 16, 2001

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Haynes; Charles A.	Vancouver			CA
Tomme; Peter	Vancouver			CA
Kilburn; Douglas G.	Vancouver			CA

US-CL-CURRENT: 435/68.1; 435/178, 435/179, 435/320.1, 435/69.1, 435/69.7, 435/70.1, 435/71.1, 435/71.2, 435/803, 435/815 , 436/529, 436/530, 530/413, 530/813, 530/814

Full | Title | Citation | Front | Review | Classification | Date | Reference | | | Claims | KWIC | Draw. De

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16. Document ID: US 6113976 A

L7: Entry 16 of 28 File: USPT Sep 5, 2000

US-PAT-NO: 6113976
DOCUMENT-IDENTIFIER: US 6113976 A

TITLE: Method of preparing reduced fat foods

DATE-ISSUED: September 5, 2000

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Chiou; Ruth G.	Decatur	IL		
Brown; Cheryl C.	Decatur	IL		
Little; Jeanette A.	Decatur	IL		
Young; Austin Harry	Decatur	IL		
Schanefelt; Robert V.	Decatur	IL		
Harris; Donald W.	Decatur	IL		

Coontz; Helen D.	Decatur	IL
Slowinski; Lori A.	Madison	WI
Anderson; Kent R.	Warrensburg	IL
Lehnhardt; William F.	Decatur	IL
Witczak; Zbigniew J.	Decatur	IL

US-CL-CURRENT: 426/661; 426/573, 426/578, 426/658

Full | Title | Citation | Front | Review | Classification | Date | Reference | Claims | KWIC | Drawu De

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☐ 17. Document ID: US 6025716 A

L7: Entry 17 of 28 File: USPT Feb 15, 2000

US-PAT-NO: 6025716
DOCUMENT-IDENTIFIER: US 6025716 A

TITLE: Magnetic resonance imaging apparatus and method for operating same

DATE-ISSUED: February 15, 2000

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Deimling; Michael	Moehrendorf			DE

US-CL-CURRENT: 324/309; 324/307

Full | Title | Citation | Front | Review | Classification | Date | Reference | Claims | KWIC | Drawu De

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☐ 18. Document ID: US 6023634 A

L7: Entry 18 of 28 File: USPT Feb 8, 2000

US-PAT-NO: 6023634
DOCUMENT-IDENTIFIER: US 6023634 A

TITLE: MR imaging using mutual interaction between different kinds of pools of nuclear spins

DATE-ISSUED: February 8, 2000

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Hanawa; Masatoshi	Otawara			JP
Miyazaki; Mitsue	Otawara			JP
Kassai; Yoshimori	Otawara			JP

US-CL-CURRENT: 600/410; 324/307, 324/309

Full | Title | Citation | Front | Review | Classification | Date | Reference | | | Claims | KMC | Draw De

19. Document ID: US 5891032 A

L7: Entry 19 of 28 File: USPT Apr 6, 1999

US-PAT-NO: 5891032
DOCUMENT-IDENTIFIER: US 5891032 A

TITLE: Fat free TOF angiography

DATE-ISSUED: April 6, 1999

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Harvey; Paul Royston	Karkur			IL

US-CL-CURRENT: 600/419; 324/306, 324/307, 324/309

Full | Title | Citation | Front | Review | Classification | Date | Reference | | | Claims | KMC | Draw De

20. Document ID: US 5650723 A

L7: Entry 20 of 28 File: USPT Jul 22, 1997

US-PAT-NO: 5650723
DOCUMENT-IDENTIFIER: US 5650723 A

TITLE: Full echo spiral-in/spiral-out magnetic resonance imaging

DATE-ISSUED: July 22, 1997

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Meyer; Craig H.	Palo Alto	CA		

US-CL-CURRENT: 324/309; 324/307

Full | Title | Citation | Front | Review | Classification | Date | Reference | | | Claims | KMC | Draw De

21. Document ID: US 5614827 A

L7: Entry 21 of 28 File: USPT Mar 25, 1997

US-PAT-NO: 5614827
DOCUMENT-IDENTIFIER: US 5614827 A

TITLE: Method and apparatus for shimming a magnet system of a nuclear magnetic resonance tomography system

DATE-ISSUED: March 25, 1997

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Heid; Oliver	Bern			CH

US-CL-CURRENT: 324/320; 324/319

Full | Title | Citation | Front | Review | Classification | Date | Reference | | | Claims | KWIC | Draw De

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22. Document ID: US 5578921 A

L7: Entry 22 of 28 File: USPT Nov 26, 1996

US-PAT-NO: 5578921
DOCUMENT-IDENTIFIER: US 5578921 A

TITLE: Magnetic resonance imaging using three-dimensional spectral-spatial excitation

DATE-ISSUED: November 26, 1996

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Morrell; Glen R.	Stanford	CA		

US-CL-CURRENT: 324/307; 324/309

Full | Title | Citation | Front | Review | Classification | Date | Reference | | | Claims | KWIC | Draw De

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23. Document ID: US 5539313 A

L7: Entry 23 of 28 File: USPT Jul 23, 1996

US-PAT-NO: 5539313
DOCUMENT-IDENTIFIER: US 5539313 A

TITLE: Full echo spiral-in/spiral-out magnetic resonance imaging

DATE-ISSUED: July 23, 1996

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Meyer; Craig H.	Palo Alto	CA		

US-CL-CURRENT: 324/309; 324/307

Full | Title | Citation | Front | Review | Classification | Date | Reference | | | Claims | KWIC | Draw De

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24. Document ID: US 5395531 A

L7: Entry 24 of 28 File: USPT Mar 7, 1995

US-PAT-NO: 5395531
DOCUMENT-IDENTIFIER: US 5395531 A
**** See image for Certificate of Correction ****

TITLE: Method for fractionating a fat composition

DATE-ISSUED: March 7, 1995

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Degen; Peter D.	Huntington	NY		
Alex; Tony	Kendall Park	NJ		
Dehn, Jr.; Joseph W.	Great Neck	NY		

US-CL-CURRENT: 210/636; 210/651

Full | Title | Citation | Front | Review | Classification | Date | Reference | | | Claims | KWIC | Draw De

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25. Document ID: US 5378286 A

L7: Entry 25 of 28 File: USPT Jan 3, 1995

US-PAT-NO: 5378286
DOCUMENT-IDENTIFIER: US 5378286 A
**** See image for Certificate of Correction ****

TITLE: Method of preparing reduced fat foods

DATE-ISSUED: January 3, 1995

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Chiou; Ruth G.	Decatur	IL		
Brown; Cheryl C.	Decatur	IL		
Little; Jeanette A.	Decatur	IL		
Young; Austin H.	Decatur	IL		
Schanefelt; Robert V.	Decatur	IL		
Harris; Donald W.	Decatur	IL		
Stanley; Keith D.	Decatur	IL		
Coontz; Helen D.	Decatur	IL		
Hamdan; Carolyn J.	Decatur	IL		
Wolf-Rueff; Jody A.	Clinton	IL		
Slowinski; Lori A.	Madison	WI		
Anderson; Kent R.	Warrensburg	IL		
Lehnhardt; William F.	Decatur	IL		
Witczak; Zbigniew J.	Decatur	IL		

US-CL-CURRENT: 127/36; 127/1, 127/38, 127/40, 127/69, 127/70, 127/71

Full | Title | Citation | Front | Review | Classification | Date | Reference | | | Claims | KWIC | Draw De

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☐ 26. Document ID: US 5304931 A

L7: Entry 26 of 28 File: USPT Apr 19, 1994

US-PAT-NO: 5304931
DOCUMENT-IDENTIFIER: US 5304931 A

TITLE: Magnetic resonance imaging techniques

DATE-ISSUED: April 19, 1994

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Flamig; Duane P.	Richardson	TX	75082	
Harms; Steven E.	Dallas	TX	75205	

US-CL-CURRENT: 324/309

Full | Title | Citation | Front | Review | Classification | Date | Reference | | | Claims | KWIC | Draw De

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☐ 27. Document ID: US 5105152 A

L7: Entry 27 of 28 File: USPT Apr 14, 1992

US-PAT-NO: 5105152
DOCUMENT-IDENTIFIER: US 5105152 A

TITLE: Magnetic resonance imaging and spectroscopy using a linear class of large tip-angle selective excitation pulses

DATE-ISSUED: April 14, 1992

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Pauly; John M.	Menlo Park	CA		

US-CL-CURRENT: 324/309; 324/307

Full | Title | Citation | Front | Review | Classification | Date | Reference | | | Claims | KWIC | Draw De

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☐ 28. Document ID: US 4999580 A

L7: Entry 28 of 28 File: USPT Mar 12, 1991

US-PAT-NO: 4999580
DOCUMENT-IDENTIFIER: US 4999580 A

TITLE: magnetic resonance imaging and spectroscopy using a single excitation pulse for simultaneous spatial and spectral selectivity

DATE-ISSUED: March 12, 1991

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Meyer; Craig H.	Menlo Park	CA		
Pauly; John M.	Menlo Park	CA		

US-CL-CURRENT: 324/309

Full | Title | Citation | Front | Review | Classification | Date | Reference | | | Claims | KWIC | Draw De

Clear | Generate Collection | Print | Fwd Refs | Bkwd Refs | Generate OACS

Term	Documents
KSPACE	45
KSPACES	2
K-SPACE	1782
K-SPACES	24
"K SPACE"	0
KX	5264
KXES	20
KY	46380
KIES	953
KYS	252
KZ	508251
(L6 AND (KSPACE OR K-SPACE OR "K SPACE" OR "KX" OR "KY" OR "KZ" OR RAW)).PGPB,USPT,USOC,EPAB,JPAB,DWPI,TDBD.	28

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Display Format: - Change Format

Previous Page Next Page Go to Doc#

L7: Entry 13 of 28 File: USPT Aug 14, 2001

DOCUMENT-IDENTIFIER: US 6275040 B1
TITLE: Designing spectral-spatial pulses

Brief Summary Text (2):
The present invention relates to designing and applying spectral-spatial pulses for magnetic resonance imaging.

Brief Summary Text (4):
Frequency selective pulses are well known in the art. One type of frequency selective pulses is a standard volume (non-spectral-spatial) pulse for fat saturation, which is applied non-spatially selective to an entire image volume, for example by applying a narrow-band pulse without a slice selection gradient. Another type of frequency selective pulse is a spectral-spatial pulse, which is used to selectively excite spins at a spatial location z and a spectral frequency .upsilon.. A particular important application of frequency selective pulses is selective imaging of water-based tissue in the presence of fat-based tissue. In this application, it is desirable that, over a very small frequency range (e.g., the difference between the frequency bands of fat and water), there be a high contrast between excited and non-excited tissue types. One technique is to selectively saturate the fat tissue, so that when the entire region is excited, the fat, which is pre-saturated, will not become excited and will not generate a significant signal. Another technique is to selectively excite the water tissue so that only it generates a signal.

Brief Summary Text (7):
It should be noted that the "fat" frequency is typically broad, in many cases, there is even a significant overlap between the broad fat band and the narrow water band. Thus, any frequency shift caused by inhomogenity is quite likely to move the target frequency of the pulse and saturate the water signal by mistake (in a fat saturation pulse) or excite the fat (in a a selective water excitation pulse).

Brief Summary Text (9):
A spectral-spatial pulse comprises a train of sub-pulses, the train being applied in synchrony with an oscillating slice selection gradient. Each sub-pulse acts only on the slice at a location z by the slice selection gradient, while the accumulation of phase along the train results in the saturation for a particular frequency .nu.. More precisely, the end-magnetization comprises a series of magnetization lobes in .nu. separated by 1/.tau. Hz, where .tau. is the delay between adjacent sub-pulses. The width of the slice s determined by the slice selection gradient. In selective fat/water suppression/excitation, the fat-water frequency separation is matched to the spectral-spatial pulse such that one of the frequencies of water and fat are inside a magnetization lobe and the other is outside a magnetization lobe.

Brief Summary Text (14):
and TRF is the duration of the RF pulse. In type I pulses, TRF is about equal to .tau./2, since there is no RF over half of the gradient (the negative part). In type II pulses, TRF is about equal to .tau.. Thus, S for type II pulses can be about three times as large as for a type I pulse using same maximnum gradient amplitudes and slew rates. Consequently, the slice width of a type II pulse can be

about 1/3 the width of a comparable type I pulse. This is a requirement in high-field MRI, in which minimum slices widths are desired, even as the fat-water frequency separation increases.

Brief Summary Text (15):
A limitation of type II spectral-spatial pulses is that they have many magnetization lobes. FIG. 2 illustrates the M.sub.xy magnetization profile of a prior art type II selective water excitation pulse. However, this pulse is not useful for fat-water separation, since both the fat and the water fall on magnetization lobes and both are excited. It is noted that in this example the water frequency falls on an even lobe and the fat falls on an odd lobe. These lobes have a different behavior, for example, the transverse magnetization (M.sub.xy) of the odd lobe is antisymmetric in the z direction (not shown in the figure which is an amplitude rendition). In one known method, this anti-symmetric behavior is assumed to provide a zero average fat excitation across the slice, with the signal from fat tissue in one half of the slice being canceled by the signal in the other half of the slice, which has an opposite phase.

Brief Summary Text (16):
"Consistent Fat Suppression with Compensated Spectral-Spatial Pulses", by W. Block, J. Pauly, A. Kerr and D. Nishimura, in Mag. Res. Med., Vol. 38, pp. 198-206, the disclosure of which is incorporated herein by reference, describes a method of canceling the effect of magnetization lobes in a type II pulse. The same scan is run twice, once with a gradient function G and once with a gradient function -G. The even magnetization lobes are the same for both data sets. However, the odd magnetization lobes have an opposite polarity in the two sets. Thus, when the data from the two data sets is added together the effect of the odd magnetization lobes, e.g. the fat signal, is subtracted out. However, this method cannot be used for saturation pulses, since saturation is not signed like excitation. Also, two excitations are required, so this pulse sequence is applied over a longer period of time than a type II pulse. In addition, this sequence is more sensitive to patient motion. Another method with similar disadvantages is described in "Simultaneous Highly Selective MR Water and Fat Imaging Using a Simple New Type of Spectral-Spatial Excitation, by F. Schick, in Mag. Res. Med., Vol. 40, pp. 194-202 (1998), the disclosure of which is incorporated herein by reference.

Brief Summary Text (19):
An aspect of some preferred embodiments of the invention relates to independently controlling characteristics of odd and even magnetization lobes generated by a type II spectral-spatial pulse. In a preferred embodiment of the invention, the amplitude of odd lobes is controlled independently of the amplitude of even lobes, by shifting all the lobes along the synthesizer frequency axis. In a preferred embodiment of file invention, the shifting of the lobes causes one of the odd lobes to approximately coincide with the center synthesizer frequency. The odd lobes are found to be dependent on their off-center frequency and thus achieve an approximately zero amplitude at the center frequency. In a preferred embodiment of the invention, only a single magnetization lobe is canceled at or about a fat/water boundary or another type of frequency selection boundary. In a preferred embodiment of the invention, the lobe translation is achieved by adding a phase shift between each adjacent sub-pulses.

Brief Summary Text (25):
An aspect of some preferred embodiments of the invention relates to spectral-spatial pulse design. In a preferred embodiment of the invention, minimum phase equi-ripple FIR filters are used for designing spectral-spatial saturation pulses and their constituent sub-pulses. In a preferred embodiment of the invention, the resulting sub-pulse is time inverted, for use in negative-gradient sub-pulse trains, to correct for a reverse direction of advance in k-space during the negative gradient. Alternatively or additionally, the RF is resampled using a VERSE process to allow the RF to be applied also when the gradient is not at a constant

amplitude. Preferably, the inverse SLR process is applied on the unevenly sampled results of the VERSE sequence, by interpolating between them, preferably using a Fourier interpolation

Brief Summary Text (33):
There is also provided in accordance with a preferred embodiment of the invention, a method of affecting magnetization vectors in magnetic resonance, comprising:

Brief Summary Text (44):
alternately adding and subtracting said phase shift between adjacent sub-pulses of said pulse. Preferably, said distortion is caused by eddy currents. Alternatively or additionally, said distortion effects a phase shift between a synthesizer of an MRI system used for applying said pulse and spins which are to be affected by said pulse. Alternatively or additionally, said phase shift is dependent on an off-center position for which said pulse is designated. Alternatively or additionally, said alternatively adding and subtracting said phase shifts comprises phase shifting a system synthesizer used for generating said pulses. Alternatively, said alternatively adding and subtracting said phase shifts comprises adding and subtracting a phase shift relative to a fixed system synthesizer used for generating said pulses.

Drawing Description Text (5):
FIG. 2 illustrates an M.sub.xy magnetization profile of a prior art selective water excitation pulse;

Drawing Description Text (8):
FIG. 5 illustrates an M.sub.xy magnetization profile of a selective water excitation pulse, in accordance with a preferred embodiment of the invention;

Drawing Description Text (9):
FIG. 6 illustrates an M.sub.z magnetization profile of a selective fat saturation pulse, in accordance with a preferred embodiment of the invention;

Detailed Description Text (11):
In another way of viewing the situation, the odd lobes are generated for a frequency .nu. because of the mismatch between the positive and the negative paths in k-space. Thus, the odd lobe is smaller if .vertline..nu..vertline. is smaller, and is zero at .nu.=0. However, it is noted that an even lobe M.sub.0 is generated at .nu.=0. Another result of the anti-symmetry of odd magnetization lobes is that odd lobes must have a zero amplitude for all frequencies .nu. if z=0.

Detailed Description Text (12):
FIG. 4A shows a magnetization profile of a prior art type II selective water excitation pulse. The center frequency .nu. is centered on the water frequency to be excited. However, due to the small fat-water separation and due to the existence of odd magnetization lobes, the fat frequency also coincides with a magnetization lobe, so there is less of a selective excitation.

Detailed Description Text (13):
In a preferred embodiment of the invention, an odd lobe is canceled by translating that odd lobe (preferably using a method described below) towards the synthesizer frequency, so that its amplitude is reduced (to zero at the exact frequency). In a preferred embodiment of the invention, all the lobes are translated as a unit, so that the even lobe M.sub.0 is translated away from the synthesizer frequency. Thus, there will be no excitation at the synthesizer frequency. In a preferred embodiment of the invention, the center frequency is chosen to be that of tissue which is not to be excited, for example fat, and .tau. is selected so that the tissue to be excited coincides with a magnetization lobe. FIGS. 4B demonstrates this selection, whereby odd lobe M1 is centered on frequency .nu., coincides with the fat frequency and has a zero amplitude and the water frequency coincides with lobe M.sub.2, which

has a none-zero amplitude. It is noted that the term "translation" is not precise, as the amplitudes of at least some of the odd lobes are affected by the translation.

Detailed Description Text (14):
In a preferred embodiment of the invention, the odd and even lobes are translated by 1/2.tau., so that the odd lobe will coincide with the center frequency .nu..sub.0 rather than the even lobe. In a preferred embodiment of the invention, the translation is achieved by adding a phase shift of .pi. radians between adjacent sub-pulses. The present inventor has determined that by adding a particular phase shift between adjacent pulses, the position of the lobes relative to the synthesizer frequency can be controlled. Typically, by design, the center of the even magnetization lobe M.sub.0 sits at a frequency where the phase between consecutively applied sub-pulses is zero. When a positive phase is added between sub-pulses the frequency where there is zero phase between the sub-pulses is shifted to a lower frequency such that the added phase is canceled. This causes all the lobes to be shifted by the same frequency shift.

Detailed Description Text (15):
The method of adding the phase shift can preferably depends on the MRI system used For example, in some systems, such a phase shift is added by adding a phase shift of the transmitted RF relative to the synthesizer. In other systems, the phase shift is modified by directly controlling the synthesizer phase.

Detailed Description Text (16):
FIG. 5 illustrates an M.sub.xy magnetization profile of a selective water excitation pulse as described above with reference to FIG. 4B. The pulse parameters are described below.

Detailed Description Text (19):
FIG. 6 illustrates an M.sub.z magnetization profile of a selective fat saturation pulse, in accordance with a preferred embodiment of the invention. The pulse parameters are described below.

Detailed Description Text (25):
In a preferred embodiment of the invention, the negative polarity RF sub-pulses are inverted in time relative to the positive polarity RF pulses, because the k-space trajectory is inverted by the opposite field polarity. This is especially relevant for the minimum phase filter which is significantly asymmetric in time.

Detailed Description Text (28):
As described above, a phase shift may be added between adjacent sub-pulses in order to translate the magnetization lobes in a desirable manner. Unfortunately, an undesirable translation may be caused by field variations, caused for example by imperfections in the systems, possibly resulting in excitation of tissue which was not supposed to be excited or vice versa. In typical MRI systems, the gradients are not directly controlled. Instead, a feedback circuit is used to drive the gradient coils. The delay between the control of the circuit and the response of the gradient coils is neither zero nor exactly known. Further, in order to reduce feedback effects, various filters are used in the feedback circuits, which filters further affect the output of the gradient coils. In addition, eddy currents, induced by the gradients can add an additional offset to the applied gradients. As a result, the actually applied gradients are not the same as those for which the pulse was designed. It should be noted that spectral-spatial pulses are often applied at the highest slew rates achievable by the MRI system at which high slow rates the system is not entirely controllable. The RF is usually controllable to a higher degree than the gradients. The application of the RF is typically synchronized to a synthesizer. This synchronization includes both temporal synchronization and phase synchronization. Thus, the phase of the RF is typically locked (or phased shifted relative to) the phase of the synthesizer frequency.

Detailed Description Text (31):
In FIG. 8, the gradient delay .DELTA.t between f(t), which follows the ideal gradient demand and the actual gradient output adds a phase shift .psi..sub.0 of 2.gamma.z.sub.i G.DELTA.t during the gradient fall between an odd and an adjacent even sub-pulse, where G is the peak amplitude of the gradient. This affected area is equal to the dotted area in FIG. 8. A same type of area is also can also be generated by other types of distortions. However, a phase shift of -.psi..sub.0 is generated during the gradient raise. Thus, for a type I pulse, the two phase shifts cancel each other out, resulting in a zero phase shift between two adjacent odd or even sub-pulses. However, for a type II pulse, the effect of this phase shift accumulates and causes a shifting of the amplitude of magnetization between odd lobes and even lobes.

Detailed Description Text (34):
There are several types of eddy currents, including currents having a time constant smaller than .tau., about similar to .tau. and those having a time constant greater than. The long-decay eddy currents are usually compensated for in MRI systems. In addition, these eddy currents typically have a small effect on the outcome of the pulse. So, in some preferred embodiments of the invention, these eddy current are ignored. The effect of short duration eddy-currents (time factor significantly smaller than .tau.) is usually a same effective phase shift (with an opposite sign for the rise and the fall), which treated as described above.

Detailed Description Text (35):
In a preferred embodiment of the invention, one, two or more dummy gradients are applied prior to applying the RF pulse, so that eddy currents having a time constant of about .tau. reach a steady state of behavior. Preferably, if the length of the dummy gradients is about two times that of the eddy current time constant, the phase shift alternates between +.psi. and -.psi. (as with the short duration eddy currents) Thus, at least in a type I pulse, the rising and filling phase shifts can cancel each other out. In a preferred embodiment of the invention, the eddy currents having a time constant of about .tau., are determined using any of the methods known in the art. Then, a simulation is performed to determine the number of dummy gradient required to achieve a steady state. Typically however these eddy currents are already compensated for in well-calibrated MRI systems.

Detailed Description Text (55):
4. Determining N, the FIR bandwidth and the ripple parameters based on the frequency transition width and the type of pulse (water selective or fat selective).

Detailed Description Text (60):
The above discussion has been generally to fat saturation (or water excitation), however, it should be appreciated that the above methods of designing and applying type I and type II spectral-spatial pulses may be applied to other situations where frequency selective imaging and/or saturation is desired, for example, spectroscopy.

Detailed Description Text (62):
It will be appreciated that the above described methods of spectral-spatial pulse design may be varied in many ways, including, using the pulse for tree-dimensional imaging, using real or complex pulses and sub-pulses, changing the order of steps, which steps are performed off-line and which on-line and the order of steps. In addition, a multiplicity of various features, both of method and of devices have been described. It should be appreciated that different features may be combined in different ways. In particular, not all the features shown above in a particular embodiment are necessary in every similar preferred embodiment of the invention. Further, combinations of the above features are also considered to be within the scope of some preferred embodiments of the invention. Although the present

invention has been described mainly as methods, apparatus for performing the methods, especially MRI equipment with suitable hardware and/or software are also within the scope of the invention. When used in the following claims, the terms "comprises", "comprising", "includes", "including" or the like mean "including but not limited to".

Other Reference Publication (1):
Schick, F.; "Simultaneous Highly Selective MR Water and Fat Imaging Using a Simple New Type of Spectral-Spatial Excitation"; Magnetic Resonance in Medicine; vol. 40; pp. 194-202; 1998.

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Meyer, Craig H. et al.; "Simultaneous Spatial and Spectral Selective Excitation"; Magnetic Resonance in Medicine; vol. 15; pp. 287-304; 1990.

Other Reference Publication (3):
Hore, P. J.; "Solvent Suppression in Fourier Transform Nuclear Magnetic Resonance"; Journal of Magnetic Resonance; vol. 55; pp. 283-300; 1983.

Other Reference Publication (4):
Man Lai-Chee et al.; "Improved Automatic Off-Resonance Correction Without a Field Map in Spiral Imaging"; Magnetic Resonance in Medicine; vol. 37; pp. 906-913; 1997.

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Man Lai-Chee et al.; "Multifrequency Interpolation for Fast Off-Resonance Correction"; Magnetic Resonance in Medicine; vol. 37; pp. 785-792; 1997.

Other Reference Publication (7):
Purdy, David E. et al.; "Improved Multi-Slice Fat Suppression in Inhomogeneus Fields Using Variable-Frequency Spectral-Spatial Water Excitation Pulses"; Siemens Medical Systems; pp. 653; 1995.

Other Reference Publication (9):
Harvey, Paul R. et al.; "Fat Free Angiography Using Flow Compensated Binomial-Spectral-Spatial-Slice-Variable-Tip-Angle RF Slice Selection"; Elscint MRI Centre; Israel; 1997.

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Other Reference Publication (12):
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Other Reference Publication (13):
Conolly, S. et al.; "A Reduced Power Selective Adiabatic Spin-Echo Pulse Sequence"; Magnetic Resonance in Medicine; vol. 18; pp. 28-38; 1991.

Other Reference Publication (14):
Reeder, S. B. et al.; "Referenceless Interleaved Echo-Planar Imaging"; Magnetic Resonance in Medicine; vol. 41; pp. 87-94; 1999.

CLAIMS:

11. A method of affecting magnetization vectors in magnetic resonance, comprising:

providing a type II spectral-spatial pulse having odd and even magnetization lobes; and

modifying at least one parameter of said pulse to independently control a characteristic of said odd lobes with respect to said even magnetization lobes, wherein said at least one parameters includes at least one relative phase shift of between at least two individual sub-pulses of said pulse, and wherein modifying comprises modifying said at least one parameter to reduce the amplitude of a particular magnetization lobe.

Previous Doc Next Doc Go to Doc#